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WHEAT,

ITS WORTH AND WASTE:

WITH

ORIGINAL MICROSCOPIC ILLUSTRATIONS.

BY

WM. HAND BROWNE,

AND

THOS. J. HAND.

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WHEAT,

ITS WORTH AND WASTE.

ELEMENTS OF FOOD.

The various substances used by man as food, however differing in appearance, origin, or sensible properties, may be ranged, as Physiology has shown us, under two great classes—the azotised, and the non-azotised; or those which contain nitrogen and those which are destitute of it. The office of the former is to replace with new material the perpetual waste and wear of all the tissues of the body; while that of the latter appears to be the maintenance of animal heat by slow combustion with oxygen. This latter service, however, can be performed by the substances of the first class; but those of the second class cannot take the place of the former in building up the tissues, being deficient in the essential element, nitrogen: in other words, man can live on a diet of azotised substances, while on a strictly non-azotised diet he perishes.

The azotised alimentary substances, therefore, are those which are absolutely indispensable to human life.

Notwithstanding the innumerable varieties of food used by man, some peculiar to certain countries or climates, and others the common heritage of the human race, they all agree in containing one or more of these azotised or nutrient principles, which, as far as is now known, are only four in number, viz:—

Fibrin, Animal;
Gluten, Vegetable;
Casein, Animal or Vegetable;
Albumen, Animal or Vegetable.

So closely do these principles agree in chemical composition and properties, that a distinguished physiologist has considered them mere modifications of one substance, to which, as the nutritious principle, or food proper, he gives the name of Protein.

The non-azotised substances differ more from each other, both in appearance and chemical composition, than do the Protein compounds ; but they all have two important qualities in common : they combine readily with oxygen, under favorable circumstances, and by such combination they produce water and carbonic acid, with an evolution of heat.

The most important of these substances are

SUGAR and STARCH,	Vegetable products ;
OILS and FATS,	Vegetable or Animal.

Every substance which forms a chief article of food must contain at least one representative of each of these two great classes, thus :—

Meat	contains	Fibrin and Fat.
Milk	"	Casein and Fat.
Fruit	"	Gluten and Sugar.
Grain	"	Gluten and Starch.

And those substances become, in an economical point of view, the most important articles of diet, which furnish the greatest quantity of these elements at the least cost of production.

WHEAT.

Pre-eminent among nutritious substances, for the reason just given, stand the four species of grain which bear the collective name of Cereals : Wheat, Rye, Oats and Barley, and of these by far the most important is Wheat. Its ready adaptability to different climates and soils, the facility of its cultivation, its abundant yield, and the excellence of the food prepared from it, have made it the favorite with all agricultural nations, and justify its title of the Queen of the Cereals.

The five hundred different varieties of wheat now known* have, no doubt, been developed by ages of cultivation from one primitive stock ; but for so vast a period of time has this grain been under

* M. Philippar's Report to the Acad. of Sciences mentions 483.

the culture of man, that, as with some of the domestic animals, its origin and the place of its nativity are entirely unknown.

These numerous varieties of wheat, however distinguished by the form or color of the grain, by the size of the straw, by the presence or absence of the beard or awn, by the time of ripening, etc., can all be arranged under two great classes, the *soft* and the *hard* wheats. The soft wheats are the growth of cooler or more northern latitudes, and the hard wheats, of warmer climates ; the former are more abundant in starch, with comparatively but little gluten, while the latter have the gluten in greater proportion.

When a thin transverse section is made of a grain of wheat, and submitted to a microscope, it presents an appearance represented in Fig. 1.

Fig. 1.

GRAINS OF WHITE WHEAT, NATURAL SIZE, A TRANSVERSE SECTION, AND THE SAME MAGNIFIED TO 18 DIAMETERS.

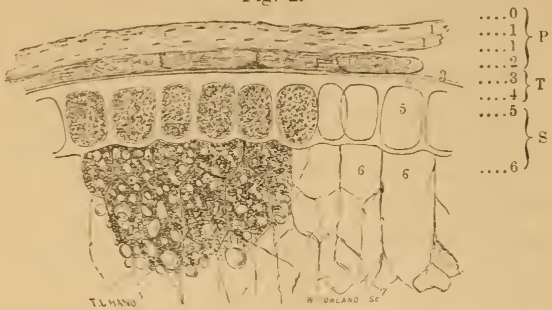
On the outside is seen the Husk or pericarp, consisting of an outer and inner coat (the true brans) which adhere closely to each other, and may be regarded as one skin ; next,

A layer of cells containing Gluten, with some oil and perhaps albumen ; and then

The central mass of the grain composed of cells which are filled with granules of Starch, with, it is believed, a small proportion of gluten.

Its structure will be better understood by reference to the next cut of a portion of such section, much more highly magnified.

Fig. 2.



PORTION OF TRANSVERSE SECTION OF WHITE WHEAT, 150 DIAMETERS.

1.1	Double cellular coat, outer True Bran,	BRAN or HUSK proper.
2	Single cellular coat, inner True Bran,	
3	Testa; a filmy cellulose membrane.	
4	Inner cellulose membrane, covering gluten cells.	
5	Sack-like cells containing GLUTEN, (some shown with gluten removed).	
6	Cells forming the central mass, containing STARCH, with some gluten, (contents of some cells removed).*	

* The above simple classification was adopted for these original illustrations (drawn on wood under the camera lucida of the microscope) as best suited to the purpose of this memoir. The same figures, 1, 2, 3, &c., will be found in the subsequent cuts, designating the same coats to which they are here respectively assigned.

The figures and letters adjoining the engraving are inserted for reference to the subjoined and more minute classifications of MM. Mouriès and Trécul.

0	Cuticle proper; "epicarp" of Mouriès.	P pericarp. (Trécul.)
1 1	"sarcocarp" "	
2	"endocarp" "	
3	Testa, or primine. (Trécul.)	T proper teguments. (Trécul.)
4	Inner membrane or secundine, (Trécul.)	
5	First layer of cells,	S part of perisperm. (Trécul.)
6	Commencement of starch cells.	

The teguments are more distinctly illustrated in Fig. 4, which see.

THE HUSK.

The husk or true bran is composed of thin membranes of woody fibre, and constitutes the outer covering of the grain. It adheres so firmly to the teguments investing the gluten cells beneath it, that when the wheat is in a dry state it is almost impossible to detach it without tearing these cells away. Different analysts have estimated the proportion of weight of the husk to the entire grain, with results varying from 2 to 5·72 per cent. The great divergency of these estimates is no doubt mainly due to the varieties in the grain itself; as not only would the various thicknesses of the integuments, giving

Fig. 3.

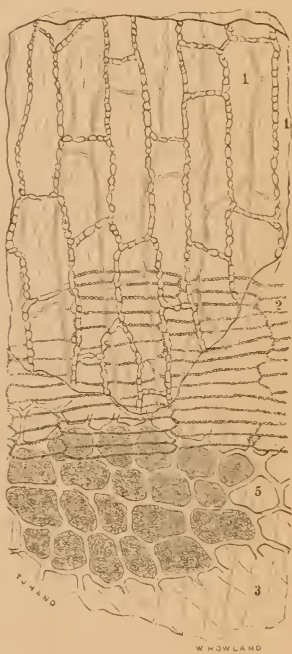


Fig. 3 exhibits the successive coats, freed from adhering starch cells, under a magnifying power of 150 diameters, the outermost being nearest the observer's eye.

The cuticle, (or epicarp,) a structureless membrane, is not distinguishable in this section, on account of its extreme tenuity and transparency.

1 The outer true bran (sarcocarp), composed of a double layer of cells, elongated parallel with the axis of the grain. In the cut the outlines of the second layer are dimly defined beneath the beaded divisions of the first, which was precisely in focus. The cells of the inner layer are not exactly like those of the outer; they are less distinct in definition, and not conspicuously *beaded.* The cells of both layers are less oblong and more irregular in shape as they approach the ends of the kernel, the skin thickening and roughening in these directions, and presenting, especially towards the base of the grain, a darker hue and more woody texture.

2 Under this double coat is seen the inner true bran (endocarp), with its delicately beaded cells lying at right angles to those of the outer coat.

3 The testa is next perceived overlying and extending beyond the group of gluten cells. In the unripe grain it is seen to consist of a single layer of cells containing a very fine granulous substance of a yellowish or brownish color (Trécul); but in mature wheat, to which our own investigations have been limited (as in the present specimen), the cell-structure can no longer be

rise to the distinctions of *thick-skinned* and *thin-skinned* wheat, produce these differences, but the *plumpness* or *meagreness* of the grains analysed would affect the proportion of the husk to the entire body.

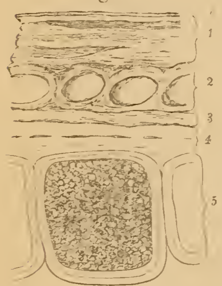
The true bran is entirely destitute of nutritious properties. It absorbs water very readily, and when damp is extremely liable to must or mildew.

If a quantity of this true bran (not the ordinary bran of millers) be dampened and left in a mass, it speedily sours, emitting pungent acetic fumes. As no starch is present, this must be the result of a degeneration of the *lignin*, or woody fibre, into sugar, alcohol and acetic acid. Its proclivity to this decomposition is quite remarkable, and is no doubt one of the causes that many persons find bran-bread so irritating to their digestive organs.

Certain principles have also been recently detected in it which are supposed to exert an influence in the conversion of starch into sugar. This will be further noticed hereafter.

defined, and the most careful engraving fails to do justice to its delicate filminess. It is this membrane which gives the characteristic colors to the different varieties of the grain, varying from a pale yellow tint in white, to a deep orange in hard red wheats.

Fig. 4.



Portion of Radial (or longitudinal) section, 400 diameters.

4 The inner membrane, or secundine, although thicker than the testa, is not visible in this drawing (Fig. 3) on account of its extreme transparency, and when presenting its edge in a cross section, its line of contact with the sacks containing gluten can only be defined under a much higher magnifying power, (as shown in Fig. 4.) Like the testa, it is composed in the unripe grain of a single layer of cells. As the grain ripens, the outer and inner walls of these cells thicken, while the partitions between them diminish and disappear, until the whole coat seems to consist of two thick, homogeneous plates in close contact, but leaving here and there occasional lacunæ as remains of the original cell structure. (Trécul.)

5 This, the first layer of cells, consists of a series of separate sacks compressed by crowding into irregular shapes, and averaging $\frac{1}{675}$ of an inch in diameter in the specimens examined. These sacks are filled with gluten. mingled with a small proportion of oily and albuminous matter ; the gluten being in the form of minute granules, about $\frac{1}{15000}$ of an inch in diameter. When the sacks are ruptured and the contents forced out, the particles of the latter adhere to each other with great tenacity.

STARCH.

This, as has been previously mentioned, is a substance containing no nitrogen, and consequently incapable alone of sustaining life. It forms almost exclusively the entire central mass of the grain, and though greatly varying in quantity in different specimens, it always exceeds in weight all the other principles together.

Under the microscope wheaten starch appears in the form of somewhat elongated globules, varying in the same kernel of wheat from $\frac{1}{850}$ to $\frac{1}{7000}$ of an inch in diameter. Upon closer investigation these globules are discovered to be composed of an exquisitely fine transparent membrane inclosing a gummy substance.

To the unassisted eye starch presents itself in the form of a white, opaque powder ; it is insipid, inodorous, and gives a peculiar crackling sound when pressed between the fingers. Its specific gravity is 1·53. It is insoluble in ether, alcohol or cold water. Boiling water dissolves it readily by bursting the membranous envelope of the globules, and allowing their gummy contents to escape. After moderate torrefaction it becomes soluble in cold water, in which state it presents a strong analogy to gum, and bears the name of *dextrine.* By a slightly increased temperature, or by the addition of sulphuric acid, this dextrine undergoes a very interesting change, and is converted into *sugar.* The same process takes place under organic laws in the ripening of fruits, where the hard and insipid or acid mass is gradually transformed into a soft and saccharine pulp. It also explains the action of heat in culinary processes, by which the insoluble and consequently indigestible starch of the flour or vegetable is rendered soluble and fit for food.

M. Mouriès, of Paris, in 1854 presented a memoir to the Academy in which he declares that he has discovered in ordinary bran certain principles which effect this change in starch without the necessity of so elevated a temperature. In one of his experiments, 100 parts by weight of starch, made into a paste with 1500 parts of infusion of bran at a temperature of 104° Fahrenheit, were liquefied in 20 minutes. After standing two hours, the solid residue was only 15·13, and the fluid upon evaporation left 85 parts of dextrine and sugar.

This phenomenon seems to have an intimate relation with the action of *diastase*, a singular organic substance usually prepared from germinated barley, or malt, which possesses the remarkable property, at a moderate temperature, of rendering the starch globules instantly soluble, and of converting them gradually into sugar. In the experiments of M. Guérin-Vary, 100 parts of starch, made into a paste with 1393 parts of water, to which were added 12·25 of diastase, dissolved in 367 of cold water, and maintained at a temperature of 68° Fahr. for 24 hours, yielded 78 per cent. of sugar. The importance of these phenomena in the process of bread-making will be subsequently seen.

GLUTEN.

When a mass of wheaten dough is washed under a gentle stream of water upon a fine sieve or hair-cloth, and the washing is continued until the water which passes through ceases to present a milky appearance, there is left upon the sieve an elastic viscid substance of grayish color, insipid, and with but slight odor. This is the *gluten*, the most important element of the grain, and its true nutritive principle. It is to this substance that wheat flour owes its property of panification ; and it is the abundance of gluten that has distinguished the cereals from all other grains, and placed wheat as the chief of the cereals.

Dry gluten is insoluble in alcohol, ether or the oils ; it saponifies with potash, and dissolves in the mineral and acetic acids. Hot nitric acid decomposes it, and converts it into acetic, malic and oxalic acids, with a bitter substance ; a process which throws additional light on the ripening of fruits. Water does not dissolve it, but converts it into a viscid mucilage. It has, however, when pulverised, a remarkable affinity for water, in which peculiarity it entirely differs from starch. Vauquelin says that fresh gluten in the natural state contains about $\frac{2}{3}$ of its weight of water, and that 'of the 45 or 50 parts of water which a quintal of flour will absorb, nearly one half is appropriated by the gluten, the rest only serving to moisten the surfaces of the particles of starch, as it would moisten so much fine sand.'

Like all organic substances of high grade, it very readily undergoes putrefaction, giving off a disagreeable animal odor.

Being insoluble in water, and combined with a small proportion of oily matter, it forms, upon the grain, a water proof varnish between the husk and the starch, which for a long time prevents the moisture which the former readily absorbs, from reaching the latter. When the husk has become musty or mildewed, as easily happens from dampness or imperfect ventilation when the grain is in mass, the gluten long resists this contamination and protects the starch. This, no doubt, is a natural provision to defend the germ of the future plant from disease or noxious atmospheric influences, but in an economic point of view it becomes a fact of great importance, which will again be noticed.

The proportion of gluten in wheat varies greatly according to the variety, the place and mode of cultivation, and the time of cutting the grain. The hard varieties of wheat and those raised in warm climates, as was said before, are the richest in it.* When the soil has been dressed with manures rich in nitrogen, its proportion is greatly increased. The best English flour (under the present mode of grinding) averages about ten per cent. of dry gluten, and French flour of equal grade, rather more. The flours of Odessa and Sicily are peculiarly rich in gluten. Many hundreds of analyses made by various chemists, are on record, some showing very remarkable results, among which Boussingault's report of thirty-three, and thirty-five and one-tenth per cent. of gluten in wheat raised in the Jardin des Plantes probably reaches the maximum ; but there is usually a difficulty in determining whether the analyst used flour ground in the ordinary manner, or prepared it himself from the whole grain, which makes a most important difference in the proportion of gluten.

In grain cut before it is properly matured, the gluten is remarkably deficient. In a comparative analysis of two samples of Narbonne wheat, the one cut 18 days before ripeness and the other quite ripe, the former contained six, and the latter twelve per cent.†

* Alabama flour is considered to yield 20 per cent. more bread than that of Cincinnati. Pat. Off. Rep., 1848. This is due to the absorption of water by the gluten.

† M. Julia de Fontenelle. Lavini gives a still greater difference. Mem. Roy. Acad. Sc. Turin. T. xxxiv.

The nutritive properties of gluten and its pre-eminent value as an article of food, have been demonstrated by numerous experiments, and attested by a host of chemists and physiologists. Pereira remarks: 'Gluten is easy of digestion; at least substances (as the 'preparations of wheat) which contain it in the largest quantity, are 'readily digested, even by invalids and dyspeptics. Gluten is highly 'nutritious, and alone is capable of the prolonged nutrition of 'animals.'

'Gluten from wheat or maize, by itself satisfies complete and pro-'longed nutrition.' *Magendie.*

In the report of a commission appointed in Paris, for the purpose of determining the nutritive value of various alimentary substances, and which was headed by the illustrious Magendie, the results of their investigations are summed up in these words:

'Gluten obtained from either wheat or maize presented a pheno-'menon we had not observed in our experiments with other organic 'immediate principles,* which in every instance excited greater or 'less aversion in the animals obliged to subsist on any one of them 'solely. Gluten, notwithstanding its odor is faint and sometimes 'unpleasant, while its taste has nothing agreeable, was taken without 'difficulty from the first day, and the animals continued to use it 'without repugnance for three months uninterruptedly.

'The animals presented all the characteristics of excellent health. 'This fact appeared the more remarkable to us, as it was in opposi-'tion to the law which seemed to result from very numerous facts 'before stated; namely, that an alimentary substance, especially if 'it be an isolated immediate principle, is not fitted for supporting 'life beyond a very limited period.

'Here, however, is a substance which without any preparation or 'seasoning, excited neither disgust nor aversion, and which alone 'nourished for a long period.'†

* Immediate or proximate principles are those which are obtained by analysis from organic substances without reducing these to their simple elements, and which still retain an organic character: as starch, sugar, the oils, &c. An ultimate analysis reduces these to their primitive elements, carbon, oxygen, hydrogen, &c.

† Report of the Gelatin Commission. Comptes Rendus, 1841.

PANIFICATION.

In addition to its importance as the true nutritious principle of wheat, gluten performs an essential part in the process of panification or bread-making.

When wheaten flour is mixed with water to the consistence of a stiff paste or dough, a small quantity of yeast being added in the mixing, and this paste is allowed to stand some hours in a moderate temperature, the mass is perceived to enlarge in volume, and bubbles or blisters make their appearance at the surface. The interior, if examined, is now found to be filled with minute vesicles or cells containing carbonic acid gas. After a while the mass becomes more fluid, acquires the taste and odor of acetic acid, and begins to diminish in volume. But if, before this latter change has occurred, it be placed in a heated oven, the process is arrested, but the gas in the cells already formed expands by the heat, and the mass further enlarges. Presently a crust is formed upon the surface, and when the mass after sufficient baking is withdrawn and cut open, it presents the well known honey-combed appearance of household bread ; soft, palatable, and easy of digestion.

This is panification in its simplest form ; a process of the highest antiquity, and practised under various modifications by nearly all the nations of the earth ; but it has been reserved for modern science, with its refined analysis and delicate instruments, to explain the nature and causes of these phenomena, and to show in the whole process a series of the most remarkable and interesting transformations known in organic chemistry.

The gluten first, upon the application of water, is distended and converted into a viscid mucilage, which envelopes the granules of starch, reducing the whole to a homogeneous paste. The yeast, by means of the peculiar principle diastase, contained in it, gradually renders soluble the starch granules, and transforms them successively into dextrine, sugar, and finally, alcohol and carbonic acid ; the quantity of starch acted upon being in proportion to the amount of yeast employed, and to the time during which the process is suffered to continue, as the ferment has the power of multiplying itself indefinitely out of the substance of the paste.

The carbonic acid, which is the result of the decomposition of the starch particles—that is, of such as have reached the final stage of their transformations—is liberated in minute bubbles throughout the entire mass of the dough, the viscidity of the gluten preventing it from escaping. The baking, which, by its heat, destroys the vitality of the ferment,—the activity of which is due to the rapid propagation of a microscopic plant of the division of Confervæ—arrests the further development of this acid, and hardens the walls of the cells which contained it, fixing the light loaf in that porous state* which, by the greater amount of surface presented to the action of the gastric fluids, so greatly assists digestion.

The part which the gluten plays in this process is three-fold : it absorbs the water, retains the gas, and expands in baking.† So peculiar to the gluten is this power of absorbing water, that a 'strong' flour, (or one rich in gluten,) may be known by the quantity of water it takes up in the mixing : in other words, a flour will absorb water just in proportion to the gluten it contains. Hence the value of a strong flour to the baker, as by its absorption of water it yields a greater weight of bread, or can be used to enrich a poor, starchy flour ; while the consumer, although in purchasing such bread he buys more water to the pound, actually loses nothing, but is a gainer by his bargain, as the richer the bread is in gluten, the more nutritious is it, and at the same time more palatable.

The second office that the gluten performs is equally important to the production of a light loaf. Starchy flours, or what is the same thing, flours poor in gluten, will not rise well, not having sufficient elasticity and tenacity to retain the gas as it forms in fermentation ;

* In the souring of dough the alcohol is changed into acetic acid. This dissolves a portion of the gluten, and the remainder is not sufficient to retain the gas. Hence the dough becomes more fluid and 'falls' as it sours.

† Our object being to give a simple outline of the principal changes which occur in ordinary bread-making, in order to show the leading parts which the gluten and starch perform in these transformations, we forbear adverting to the disintegration of a small portion of the gluten in the early stage of the fermenting process, (and the aid which this may furnish in dissolving the starch,) as well as the 'gliadine,' 'cerealine,' and other obscure substances, into which the gluten, during the progress of its dissolution, is said to be degraded.

and pure starch, although by the admixture of yeast it gives off carbonic acid abundantly, for the same reason cannot rise at all.

The third property of gluten, or that of expanding by heat, independently of fermentation, is probably owing to the conversion into vapor of the water it contains.* 'The comparative baking qualities 'of different samples of flour,' says Prof. Johnston, 'may be judged 'of by the height to which, in similar vessels, the gluten of equal 'weights of flour is thus observed to rise.'

Thus it is seen that a given flour will yield a quantity of bread in proportion to its gluten ; and to this gluten the bread owes its most important qualities, its lightness, agreeable flavor, digestibility and nutritiousness.† 'It is the larger proportion of gluten usually contained 'in the flour of wheat,' writes Prof. Johnston, 'that renders it so much 'better fitted for the baking of bread than the flour of any other grain.'

'It is the presence of gluten in wheaten flour that renders it pre-'eminently nutritious.'—*Brande.*

'If the flour of wheat holds the first rank among substances which, 'under the form of bread, constitute a healthy and agreeable diet, 'it owes this advantage to the gluten, which is not found in the same 'proportions and possessing the same qualities in any other cereal.' —*Dumas, Chemistry applied to the Arts, Vol. IV. p.* 415.

'The principal agent of panification is the gluten.'—*Liebig.*

* An instrument called an *aleurometer* has recently been invented for determining the relative value of flours by the expansion of the gluten in a graduated tube, under regular increments of heat.

† According to the researches of a distinguished chemist of this country, a great defect in flour produced by the present method, is the reduced amount of phosphates, which are shown to exist in the gluten separated with the bran, in a quantity more than *fourteen* times exceeding that in an equal weight of superfine flour. The uses of the phosphates in the animal economy—the structure and reparation of the bones, brain, etc.—render their presence an indispensable element of nutrition, and flour (or bread) which is deficient in them, is impaired in alimentary value to the extent of such deficiency.

[It is with pleasure that we mention, in this connection, the name of Prof. E. N. Horsford, of Harvard University, from whose recent treatise on Bread-Making the above remark is derived, and to whom we are indebted for many valuable suggestions. Our thanks are also due to his assistant, Mr. George Brooks, who, under the direction of Prof. H., kindly undertook a series of elaborate analyses, some of the results of which, confirming our positions, will be found in Appendix B.]

With these facts before us, showing that to this substance wheat owes its importance, flour its commercial value, and bread its sweetness and nourishing properties, it would seem but natural that this gluten, the latest, most highly organized and most precious of all the products of the plant's mysterious laboratory, should be watched over, collected, economized, and treasured with the most vigilant care. Is this the case?

Careful experiments have shown that the husk or innutritious part of the wheat is from about 2 to 5 per cent.* of the weight of the whole grain; consequently in 270 lbs. of wheat, the average quantity required to make a barrel of flour in the present mode of milling, there should be an average loss of about 10 lbs., every particle of the grain, except this husk, being convertible into flour. *At present the ordinary weight of bran and offal to the barrel of flour, is sixty to seventy pounds.* And of what does this needless loss consist—what element of the grain is thus wantonly thrown away? IT IS THE GLUTEN.

We have seen in the structure of the grain of wheat that the principal mass of the gluten lies between the husk and the starch. Now when the grain is crushed between the mill-stones, the layer of gluten sacks breaks up into fine scales which adhere firmly to the husk, but readily detach themselves from the crumbling starch. Part of these scales by the continuous attrition of the burrs are torn from the husk and enter the bolting cloth, which from their irregular shape they pass through with difficulty, and much more slowly than the round granules of starch; on which account the 'head' and 'tail' of the bolting, as every miller knows, must be mixed together to give a good flour.†

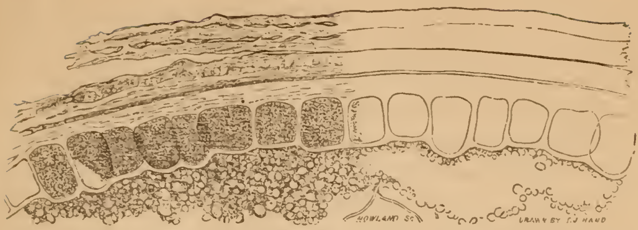
But the larger proportion adhere to the husk, and with it are separated from the flour in the form of bran and offal, as may easily be seen by an examination of fresh wheat bran, where the inner surface will be perceived to be coated with a fine varnish of gluten,‡ if indeed, this is not concealed by a layer of adhering starch.

* In a series of over 50 determinations by De Fontenelle of wheat from various parts of Europe, the highest per centage of true bran is 4·04 per cent.

† See Report of MM. Janvier and Lefèvre, Comptes Rendus, 1857, p. 88.

‡ In 1832 M. Herpin proposed to use instead of pure water, in the manufacture of bread, a cold infusion of bran. His memoir states that by a simple washing with cold water he extracted from bran 50 to 60 per cent. of nutritive matter.

Fig. 5.



TRANSVERSE SECTION OF A SCALE OF MILLERS' BRAN, MAGNIFIED TO 150 DIAMETERS; DRAWN UNDER THE CAMERA LUCIDA, PART BEING LEFT IN OUTLINE ONLY.*

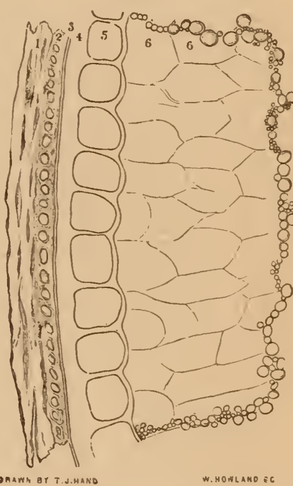
The loss by this mode of grinding, the waste of this precious gift of Nature to the human race, is incalculable. Literally incalculable. If it were merely a loss of *flour*, the figures would be startling—fifty or sixty pounds on every barrel of flour in the world are no trifling amount†—but it is a loss of the *nutritious element* of flour, of the life sustaining principle itself.‡

* This bran—from a celebrated mill—was bolted from 'high ground' *Family flour*, and our specimen represents probably *less than the average* quantity of adhering starch thus lost in the whole sample.

In making ordinary 'Super,' where the grain is subjected to 'close' grinding, the starch is nearly all separated and saved in the flour; but in this operation the husk is torn and cut so that many particles pass through the bolting cloth and render the flour 'specky,' and more liable to sour.

Fig. 6. is an outline drawing of a portion of a longitudinal section of Millers' Bran (from Family flour)--corresponding with a radial section of a kernel of wheat. Any further remarks on *waste*, in this connection, are unnecessary.

Fig. 6



[The cells in the outer coat (1) are cut lengthwise; those of the inner (2), crosswise.]

† The annual wheat crop of Europe and America is estimated at about 900,000,000 bushels, which, if all made into flour by the ordinary mode of grinding, would produce two hundred million barrels.

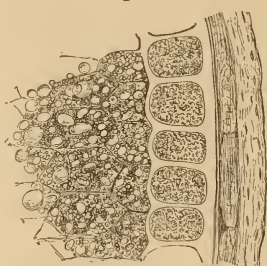
‡ See Highland Society Transactions, 1847, and Skinner's Far. Lib., Vol. III, p. 142.

Not that this loss is now for the first time discovered. Chemists and economists have long and strenuously protested against this wanton waste of food,* and have recommended the use of bread made of the unbolted meal.† But apart from the dark and uninviting color of such bread, the presence of the bran tends to make it sour readily, and the bran itself has an irritating quality that disagrees with many stomachs. Consequently many plans have been proposed and many attempts made to remove the true bran from the wheat without detaching the gluten, but they have either acted imperfectly or proved impracticable on a large scale.‡

Only quite recently has a process been perfected which accomplishes this object in the most complete manner, removing the true bran in a thin pellicle from the surface while it leaves the entire nutritious mass of the grain to be converted into flour,§ and performing this task with celerity, with regularity, and at a cost which is insignificant compared with the advantages obtained.

* Boussingault estimates 9 parts by weight of [ordinary] bran as equal in nutritive qualities to 5 of whole wheat, 28 of potatoes, or 61 of turnips.

Fig. 7.



† 'If we make a cross-section of a grain of 'wheat or rye, and place it under the micro- 'scope, we perceive very distinct layers in it as 'we examine from without inwards. The outer 'of them belong to the husk of the fruit or seed, 'and are separated as bran in grinding. But 'the mill-stone does not separate so exactly as 'the eye may by means of the microscope; not 'even so accurately as the knife of the vegeta- 'ble anatomist, and thus with the bran is 'separated also the whole outer layer of the 'cells of the nucleus, and even some of the subjacent layers. A glance at the 'figure shows, however, at once that the contents of the outer cells of the nu- 'cleus are very different from those of the inner; for while the latter inclose 'a great quantity of starch and very little nitrogenous matter, in the outer 'layer of cells we find only the latter substance, which in the cereal grains 'usually bears the name of Gluten. Thus the anatomical investigation of 'one of these corn grains at once explains why bread is so much the less nutri- 'tious the more carefully the bran has been separated from the meal' [i. e. according to the common mode of grinding.] *Schleiden. The Plant, Lecture II.*

‡ See the report of MM. Millon and Mouren of Algiers, 1853; and the report of M. Sibille to the Academy of Sciences, 1854.

§ See p. 27.

DAMAGED WHEAT AND FLOUR.

Among the numerous maladies and deteriorations to which wheat is liable, it accords with our present purpose to mention only those which affect the commercial value of the grain or flour. The chief of these are Smut, Fly, Weevil, Must, Heating and Souring.

SMUT. It is to the accomplished botanist, Bulliard, that we are indebted for the most authentic information of the nature of this disease. His researches have shown that it is a parasitic fungus of the genus *uredo*, the germs or *spores* of which, being extant in the seed when sown, or possibly effecting an entrance from without, circulate in the vessels of the plant, until finding their proper nidus in the unripe grain, they grow and propagate with excessive rapidity, being fed by the juices intended for the nutrition of the grain, which perishes away, and in its stead remain the masses of smut inclosed in the distended and altered husk. These masses are frequently of considerable size and irregular form (this is peculiarly the case with Indian corn) and on being broken open are found to contain a black powder of a somewhat unctuous feel and little or no perceptible odor. Under the microscope this is seen to consist of an aggregation of globules which are the spores or reproductive particles.*

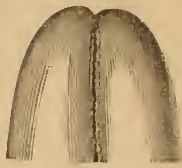
These particles are so exceedingly minute and adhere with such tenacity to substances with which they come in contact, that to remove them from the surface of sound wheat that has been contaminated by mixture with smutted grain, requires great care and peculiar machinery. And this cleaning should be thoroughly performed, for a very slight admixture of smut gives the flour a darkish appearance and greatly detracts from its commercial value.

No machinery has hitherto been devised which has perfectly accomplished this cleaning, for the reason that the impalpably fine particles of the smut accumulate in the *brush* of the wheat, (see Fig. 8.) among the fibres of which they can be seen clinging in great quantity, to be set free and mingled with the flour by the

* See also Emmons, Nat. Hist. N. Y. Part 5. Vol. II.—p. 150, and Pl. LV, with beautiful illustrations on steel.

Fig. 8.

Fig. 9.



operation of grinding. The only possible mode of removing them entirely, is by *peeling* off the true bran which carries with it the *brush* and its adherent load of smut. This is perfectly effected by the process to which we shall recur in a later page of this memoir. (See Fig. 9.—These illustrations, representing a grain of wheat in the natural state, and a portion of the same *unbranned* by machinery, are both drawn under a power of six diameters.)

THE FLY OR MOTH. If the grain when standing in the field is exposed to the ravages of vegetable parasites, no less when gathered into granaries does it suffer from the depredations of the insect tribe. Of these marauders the first to attack it is usually the fly. This is a small insect of the order of Lepidopteræ, family Nocturnæ, tribe Tineæ or Moths. The female deposits her exceedingly minute eggs upon the wheat and usually in the furrow that separates the two lobes of the grain. From these eggs are hatched small grubs or caterpillars which bore their way into the substance of the grain, remain feeding upon it for about three weeks, and then emerge, transformed into moths. Shortly before their emergence the grain will be perceived to have risen considerably in temperature, so as frequently to be unpleasantly warm to the hand.

It is said that persons engaged in handling grain infested by the moth are subject to erysipelatous inflammations; and bread made from the flour is disgusting to the taste and considered pernicious to the health of those who eat it.

The ravages committed by this little pest are immense,* and manifold expedients have been resorted to in order to escape them. Some cover the mass of wheat with a layer of moistened lime or plaster, or pack it in air-tight casks or boxes, or establish by means of perforated tubes a circulation of cool air throughout the mass. Others again wash and dry the grain, or turn and ventilate it

* In the department of Allier, France, according to M. Dumas' statement, the loss by moth in 1850 was 20 per cent., and even heavier the previous year. Comptes Rendus, 1854.

with shovels every few days, or keep it in continual motion by machinery :—processes of varying efficiency, and all expensive. Others heat it in kilns, but a temperature sufficiently high to destroy the eggs of the insect, injures the appearance of the grain and deprives it of its germinating power. Instruments have been invented, such as the *Brise-insectes* of M. Herpin, and the *Tue-teignes* of M. Doyère, for destroying both insects and eggs by a mechanical process. This is effected principally by two concentric cylinders, armed with ridges on their opposed surfaces, and the inner one revolving with great velocity. The grain passing between them receives a rapid whirling motion combined with frequent and strong percussion against the sides of the cylinders. Both instruments appear to operate effectually, and both received from the Academy the Monthyon prize 'for 'rendering an art less unhealthy.' Their chief objection seems to be the power they require.

WEEVIL. The next insect scourge whose inroads are to be feared, is the weevil; *Calandra granaria* of Latreille. And in giving an account of this small but formidable foe to our granaries, we cannot do better than to transcribe the minute and animated description furnished by Bosc, bearing in mind that his remarks are adapted to the latitude of Paris.

'As soon as the first warm days of Spring arrive, or about the 'month of April, the weevil emerge from their retreats in the 'crevices of walls, under the floors of granaries &c., and collect upon 'the heaps of grain, where the females are impregnated and where 'they deposit their eggs. These eggs are placed at a depth of 'from 54 to 81 millimetres ($2\frac{1}{8}$ to $3\frac{1}{5}$ inches) below the surface of 'the mass; never more than one egg to each grain, and this always 'in the furrow close to or directly over the germ. They are affixed 'by means of a gummy matter that covers them. The larva issues 'from this egg at the end of two, three or even eight days according 'to the warmth of the season, and gradually eats its way into the 'grain. The husk being extremely thin at the point where the egg 'is deposited, and covering the softest and sweetest portion of the 'grain, the larva has not to vanquish an obstacle superior to its 'strength, and finds a nourishment suited to its feeble condition: 'thus it grows rapidly and at the end of some twenty days it has 'devoured the entire contents of the grain. It is then transformed 'into a *nympha*, and after ten or fifteen days more, emerges by an 'aperture towards one of the ends which the larva had left. * *

'The females, two or three days after quitting their envelope, 'produce another generation, which in its turn produces a third before 'the cold weather. Thus, in the climate of Paris, according to the 'researches of Joyeuse, the descendants of a single weevil may destroy 'in the course of a summer six thousand and forty-five grains of wheat.

'In the south of France * * * * the larva arrives at its 'perfect state in about twenty-five days from its hatching; so that 'under favorable circumstances there may be six or seven generations 'of weevil in a single summer, and their ravages are so great that 'unless prompt measures are taken to check them, the wheat would 'be all destroyed. We have ourselves seen two thousand sacks of 'grain, which despite all precautions was one-half entirely destroyed, 'and the rest sold at an insignificant price.'

Analysis has shown that the weevil itself contains substances of a very noxious, not to say poisonous character; among the rest an acrid and vesicating principle similar to that of cantharides. A small quantity of the insects reduced to a paste with almond oil in a mortar and applied to the skin produces inflammation and blisters. It is easy thus to account for the violent colics and diseases of the alimentary canal so common in sections of the country infested by this pest.

The means resorted to for its destruction are similar to those adopted with the moth. Air-tight chambers, free ventilation with cool dry air, frequent stirring, heating in kilns, mechanical movement and strong percussion, have all their advocates and their peculiar merits or disadvantages. The objects to be gained are; first, to prevent the deposit of eggs, and secondly, to destroy the eggs and larvæ.

Must and Heating. The third great evil to be dreaded by the proprietor of a granary, is the result neither of vegetable nor animal life, but of organic decomposition.

All organic substances that have been sustained, as it were, by the main force of their vitality against the attacks of the oxygen of the atmosphere, the instant that vitality ceases, tend rapidly to decomposition and resolution into the elements of which they were formed. Still, by denying them the circumstances favorable to this decomposition—heat, light, air and moisture—it may be indefinitely postponed. Remarkable instances of this have occurred in the substance under consideration: the grain of wheat. This has been kept in perfectly good condition in London granaries for thirty-two years, and in Zurich for eighty years. A magazine of wheat was discovered at Sedan that was one hundred and ten years old. In 1817 a granary of wheat was found in the citadel of Metz, that had been closed in 1523, and notwithstanding its age of two hundred and ninety-four years, it made good bread. Recently stores of wheat in excellent preservation have been found among the ruins of villages destroyed by the Turks in 1526;* and it is well known that grain has been taken from sarcophagi of ancient Thebes, which, after the lapse of not less than three thousand years, preserved not merely its organic integrity but its germinating power.

These, however, are exceptional cases, showing what can be done where all favorable circumstances are united; in ordinary practice we must be content with less perfect arrangements and a shorter time of conservation.

If, however, the chief condition, the exclusion of moisture, be not complied with; if the grain be not sufficiently dry when stored, and properly guarded from atmospheric or other extraneous humidity, the process of decomposition speedily sets in. The grain begins to swell, loses its smooth and bright surface, glides less freely through the hand, and the mass soon acquires a considerable elevation of temperature and emits a penetrating musty odor. We have called this a process of decomposition, and so it is to the body of the grain; to the germ, however, it presents conditions favorable to its vitality, and if sufficiently prolonged, results in the germination or sprouting of the grain, accompanied by the conversion of a part of its starch into sugar: both processes, whether of vitality or decay, being alike fatal to its commercial and economic value.

The absorption of humidity, which is the principal cause of this mischief, is due entirely to the husk or bran. While the starch has but little affinity for water, and the gluten cells which envelope it form actually a water-proof varnish, the bran absorbs moisture with avidity from the atmosphere, and distributes it by capillarity through-

* M. Julia de Fontenelle.

out the entire mass of grain. It is in the bran that decomposition begins, and the musty odor is first perceived. If on its detection the bran be removed, the wheat is restored to its original sweetness and value; but if in this state it be ground, the contact of the musty bran with the flour imparts to it the strong disagreeable smell which no bolting or other process can remove, and which greatly deteriorates its value.

The injury resulting from this heating and musting is most enormous, and the loss of human labor and waste of human nourishment —whether occurring in granaries, warehouses, or the holds of ships— is really frightful. In the Patent Office Report for 1848 it is estimated conjecturally at from $3,000,000 to $5,000,000 yearly, and it is now probably twice that much.

The usual precautions are: cutting and cleaning the grain when it is perfectly mature and in fine dry weather, keeping it in well sheltered granaries, frequent shifting of the mass, and ventilation with dry air,* &c. Some have recommended its being packed for transportation or shipment in air-tight casks instead of sacks, kiln-drying, etc. The objection to all these methods is the expense of labor; and to the latter especially, the fact that it destroys the germinating vitality of the seed, that it impairs its appearance, and is apt to impart a scorched flavor and odor.

The true mode of protection is the removal of the bran. The grain then loses its avidity for moisture, and any dampness that it may acquire, it readily parts with by evaporation. *Unbranned* wheat may be shipped in sacks with as much safety, as far as at-

* Perhaps the most efficient mechanism for this purpose is that invented by M. Huart, and adopted by the government of France in their military storehouses on the Quai de Billy, Paris. It consists of a series of bins on various elevations, through which the grain is kept perpetually moving by means of elevators, traps, and Archimedean screws, so that the fresh air comes in contact with every particle; in addition to which it is fanned at certain stages of the process. This establishment is capable of managing 125,120 Winchester bushels, and cost $30,690. The engine which furnishes the motive force is of ten horse power. Report of MM. Janvier and Lefèvre, Comptes Rendus, 1857.

[These storehouses with their contents, valued at 2,000,000 francs, have since been destroyed by fire, originating, it is supposed, in the *dust* from the cleaning machines.]

mospheric influences are concerned, as ordinary wheat in barrels; and for wheat kept in bulk, this process is a perfect safeguard.

SOURING. This deterioration belongs to the flour, and is the cause of heavy loss, especially in cargoes shipped for long voyages. It is occasioned either by the grain having been cut too green, or ground when moist; by the flour having been allowed to heat too much in the grinding, from packing it in unseasoned barrels, and from exposure to prolonged heat or moisture after its packing. A peculiar cause, which has not received sufficient attention, is the presence of minute spiculæ of bran, too fine for the bolting-cloth to separate, distributed throughout the flour. The peculiar effect of this bran upon starch, and its tendency to initiate the process of fermentation, have already been shown.

Soured flour is readily known by its odor and taste of acetic acid, and its tendency to conglutinate into lumps (due to the formation of dextrine throughout the starch and the softening of the gluten by the acid), so that a badly soured barrel will present a solid, firm mass, instead of a light meal. It is no longer fit for panification, its gluten being altered or destroyed and the starch more or less injured; and if mixed with sound flour (as is too often done) it will superinduce the acetic fermentation in the dough or the bread.

The precautions to be observed are the same as those employed against must: careful selection of the grain, packing the flour in tight and dry barrels (rather than sacks), to be kept in a cool, dry, well ventilated place; but above all, the careful removal of every portion of the bran.

SUMMARY.

WE have now completed our examination of the grain of wheat; we have shown the nutritive value of its constituent elements and the parts they perform in panification. We have seen the immense loss of the most precious element of the grain, which is inseparable from the present mode of milling. At the same time it has been shown that the deteriorations to which both grain and flour are liable are almost entirely due—mediately or immediately—*to the bran*, which greedily absorbs dampness, affords a nidus for the eggs of insects and the spores of smut, and by its presence, in minute spiculæ, in the flour, greatly promotes its fermentation and souring. To what result do these investigations point?

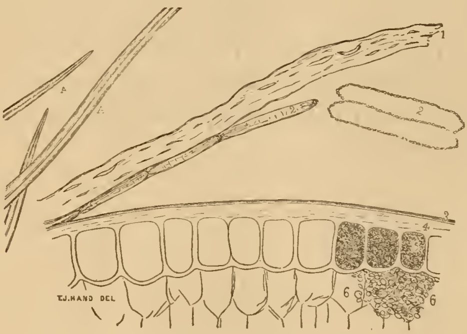
Manifestly to this;—that all this loss will be saved, that all these deteriorations will be avoided, if a process can be found *to peel the true bran from the surface of the gluten.*

THE UNBRANNING PROCESS.

We have seen on a previous page that attempts have been made in this direction, but all hitherto without satisfactory result, when tried on a scale of the necessary magnitude.

A citizen of the United States, however, Mr. Samuel Bentz, after many years of patient experiment, has perfected an apparatus equally simple, ingenious and efficacious, by which this result is most satisfactorily attained.

Fig. 10.



PORTION OF TRANSVERSE SECTION OF UNBRANNED WHEAT, 150 DIAMETERS.

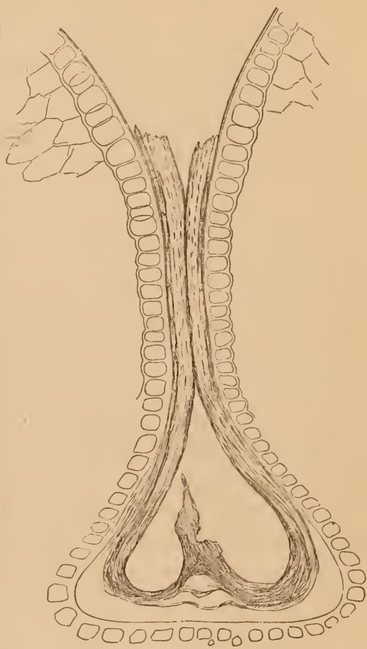
[This specimen has been taken before the operation of unbranning was complete, in order to show at what point the separation takes place.

1.2 True bran, not yet detached at one extremity. } 150
2. Detached cells of inner true bran, presenting their sides. } diameters.
AA. Portions of hairs from the *brush*, (see Fig. 8.)—100 diameters.]

The grain as it issues from the apparatus presents a beautifully smooth and polished appearance, (see Fig: 9.) and in whatever condition of uncleanness it may have entered, it emerges perfectly clean and free from dust, smut and all contamination whatever.

On close examination it is seen that *every grain has been skinned*, the true bran having been peeled from every portion of its surface (except in the *crease*, Fig. 11.) with all substances adhering to it. Microscopic investigation shows this separation to be effected between the inner true bran and testa, (i. e. between 2 and 3 ; see Fig. 10.) at the precise point where such a separation is, theoretically, most desirable; and the polished surface of the unbranned grain is due to the gluten-cells with their proper teguments.

Fig. 11.



Transverse section of the *crease* of a kernel of unbranned wheat ,—60 diameters.*
Gluten cells in outline only.

Wheat in this condition ceases to exhibit that affinity for moisture which is due to the bran, and is consequently exempt from the destructive effects of a damp atmosphere when stored in granaries or shipped on long voyages; while between the millstones the whole of its substance (except the small proportion of bran in the crease) is converted into flour.

By this economy of the gluten, the yield of grinding is of course largely increased, and the flour containing a full proportion

* Lest an exaggerated idea should be formed, from the above cut, of the proportion of bran left in the crease, it should be observed that the entire transverse section drawn on the same scale would have a diameter of about 8½ inches, and the length of the girdle of bran *removed* would be over *two feet.*

of that element, possesses a sweetness, richness and strength which flour made by the old method can never attain. By the presence of the gluten in larger proportion and its retention of moisture in the baking, the yield of bread is far greater than that made with an equal weight of ordinary flour; besides being superior in appearance, lightness and flavor to any other. From the same cause this bread remains longer fresh and moist than bread made from ordinary flour; and the freedom from particles of bran removes a chief cause of souring.

The deficiency of phosphates in ordinary flour, adverted to on a previous page (p. 15, note,) is hereby avoided;—in a word, the grain is afforded for man's consumption as nature has prepared it, but freed from the innutritious husk.

Any insects, larvæ or eggs that may be lodged upon the convexity of the grain, are of course removed with the bran; while upon any that may be in the crease, the machine operates on the same principle and with all the efficacy of the *Tue-teignes* of M. Doyère.*

The advantages of this process are co-extensive with the diffusion of the grain itself and its products. The dealer or exporter can securely store the unbranned wheat in granaries or ship it to hot climates; the miller can dispense with the complicated and costly apparatus heretofore used for cleaning, and can accomplish his grinding in a much shorter time;† the baker finds his barrel of flour produce more loaves and of finer quality; the consumer receives not only more beautiful and lighter, but sweeter and more nutritious bread; while the saving of this immense quantity of Nature's most perfect food, is a boon to the whole human family.

* This instrument, mentioned on a former page, effects its purpose by rapid percussion of the grains against the sides of a cylinder. A report made by M. Dumas to the Academy of Sciences, in 1854, declares that it perfectly destroys both insects and eggs, and it has been adopted by the French Government for all the large dépôts of military stores.

† See Appendix A.

APPENDIX A.

AN EXPERIMENTAL GRINDING BY MR J. R. PARKER, SUPERINTENDENT OF MAGNOLIA MILLS, LANCASTER, OHIO.

6.262 lbs. Blue-stem Wheat were taken.
262 " lost by unbranning, being bran, dirt and moisture.

6,000 lbs. unbranned wheat ground.

RESULTS:

26 bbls. Extra Flour. [In reality 21 Family and 5 Super, which, mixed by miller, inspected 26 bbls. Extra.]	5,096 lbs.
88 lbs. middlings, 695 " ship-stuff, &c. } [all which should have been re-ground]	783 "
Loss by evaporation, (being partly dried in unbranning)	121 "
Weight of unbranned wheat used	6,000 lbs.

In this experiment the barrel of flour was made from 3 bushels 51 pounds of unbranned wheat [or 4 bushels 1 pound crude wheat].

Bread made from $10\frac{1}{4}$ pounds of this flour weighed $18\frac{1}{2}$ pounds, giving $353\frac{3}{4}$ pounds to the barrel, instead of 240 to 260, the ordinary quantity.

Mr. Parker adds: 'The 26 barrels were ground on one stone in precisely 'five hours, at less than full speed. I am persuaded that there is a considerable saving of power in grinding wheat thus prepared for flour.'

Since in all modes of grinding, a part of the power is employed in detaching the bran from the wheat, which, in the ordinary method, is effected by the burrs forcibly tearing it off with its adherent gluten, before the starch can be effectively pulverized, experience may show that the *power saved* by grinding unbranned wheat is sufficient to perform the operation of unbranning, in which such detachment is rendered easy by the means employed: if so, the expense of unbranning will be reduced to merely the wear and tear of the machinery, and interest on its prime cost.

ESTIMATED RESULT OF SAME WHEAT GROUND IN THE ORDINARY WAY.

$18\frac{1}{2}$ bbls. Extra Flour, $4\frac{1}{2}$ " Super " }	4.508 lbs.
1.554 lbs. offal of all grades	1.554 "
Loss by evaporation	200 "
Weight of crude wheat	6.262 lbs.

APPENDIX B.

RESULTS OF ANALYSES.

NITROGEN in flour from unbranned wheat, average of two samples (Brooks' analyses)............................2·645 per ct.

GLUTEN—based on Marcet's analysis, giving 14·5 per cent. of nitrogen to that element.............................. 18·24 " "

The average per centage of gluten in English flour is 10 per cent.; that of six samples of New Jersey and New York flour (Pat. Off. Rep., 1848)................ 11·80 " "

Proportion of gluten in flour from unbranned wheat compared with that in ordinary flour, rather more than... 3 to 2

In a barrel of flour made from unbranned wheat there would consequently be 35·75 lbs. of dry gluten; in the same quantity of ordinary flour, only 23·13 lbs.

Difference per bbl. in favor of unbranned flour.....12·62 lbs.

PHOSPHATES. Phosphoric acid in flour from unbranned wheat, average of two samples (Brooks' analyses)............ 0·31 per ct.

Phosphoric acid in ordinary flour (Mayer's analysis).. 0·20 " "

Proportion of phosphates in flour from unbranned wheat, compared with ordinary flour, as............... 31 to 20

Thus confirming Prof. Horsford's statement that the phosphates and nitrogenous compounds vary in equal proportions.

We have shown the unbranned flour to contain 12·62 lbs. more *dry* gluten than ordinary flour. But gluten, in its natural state, contains (see p. 10) about two-thirds its weight of water; consequently this difference amounts to 37·86 lbs. *fresh* gluten.

M. Emile Martin, of Vervins, in a very interesting paper on the manufacture of starch, recommends that the gluten which is separated by the process employed, be mixed with wheaten dough, for making bread, in the proportion of one-fifth or one-sixth of the weight of the flour employed. By this addition he obtains a sweet and rich bread, highly nutritious and keeping well. Now it is worthy of note that this excess of gluten in unbranned flour is almost exactly *one-fifth* its weight.

Thus the unbranning process performs *for the flour* what M. Martin finds so advantageous to be done *in the dough;* and bread made from unbranned flour possesses all the advantages so highly praised in that made according to his directions.

APPENDIX C.

GRINDING UNBRANNED WHEAT.

The aim of the miller desirous of producing the best flour, is to grind his wheat in such a manner as not to crush and cake the meal, nor allow it to heat between the burrs, but to granulate it perfectly and evenly throughout, giving the 'wiry' feel characteristic of high-ground flours. Flour ground too closely, or with dull burrs that mash rather than granulate, has an unctuous feel, and is technically termed 'killed.' It absorbs but little water and its dough becomes 'runny,' or does not rise properly.

The use of very sharp burrs, however, has a drawback. They shave and cut up the bran into fine scales which speck the flour. Consequently the miller who aims at the most profitable results, has to steer between dull burrs with deadness, and sharp burrs with speckiness.

With unbranned wheat, however, this dilemma is obviated. The burrs operate, not on a *bran surface*, but on a *gluten* surface, and consequently the sharper the better.

The burrs must be in perfect face, always in good dress, and the feed never more than they can conveniently manage.

The returns of the first grinding, being necessarily clean, *should all be re-ground.* Containing a very large portion of gluten, the product of this re-grinding can be mingled entirely or in part with that of the first grinding; or it may be used to enrich the flour of more starchy wheat, at the discretion of the miller.

DIRECTIONS FOR MAKING BREAD FROM THE GLUTEN FLOUR.

Mix a very thin dough about twelve hours before baking, using luke-warm water (or milk if preferred), and fresh, sweet yeast. When the sponge has risen, and begins to show a slight depression in the centre, add more flour, water and a little salt, and *knead most thoroughly.* Make the loaves smaller than usual, set them before the fire, and as soon as they begin to rise (they will rise one-third higher than when made of other flour) put them into the oven.* Dough is often allowed to stand too long before baking, by which the bread loses its finest flavor and becomes chaffy. Be careful not to have too much heat at first, or it will form a hard crust round the loaf too soon,

* Some bread-makers prefer, after *thorough kneading*, to let the 'batch' rise, and then form it into loaves (smaller than usual) for the pans, and when they have risen enough, put them into the oven.

and the escaping gas will lift one side of the loaf, bursting it and rendering it shapeless, while it hinders it from acquiring a proper sponginess. When the crust is somewhat darker than straw-color it is right. Be sure to let it bake long enough not to be 'clammy' when cut. When baked, wrap up the bread in a cloth until it cools; unless a crisp, hard crust is preferred, in which case it may be left to cool, uncovered. on a table.

☞ Weigh the flour used, and compare with its weight that of the bread when baked.

If it is desired to make bread without the use of ferment, pass the flour, with the proper proportion of yeast powder and salt, two or three times through a sieve, that they may be evenly and intimately mingled. Mix the dough as soft as possible—milk being far preferable to water—and *knead it well.* The tenacity of the gluten being developed by the kneading, it will the better retain the gas and insure sponginess. Place the loaves in covered pans, sufficiently deep to allow room for expansion of the dough. They should be well baked.

In whatever way bread is made, remember that this flour takes *more water*, and requires *more kneading* than other flour; but especially THOROUGH KNEADING.

TABULAR STATEMENT

OF

SEVERAL GRINDINGS OF BENTZ'S UNBRANNED WHEAT.

Where Ground.	Bushels of Wheat delivered.	Barrels Flour produced.	Grades of Flour, and their proportions.	Bushels of crude Wheat to barrel.	Bushels of unbranned Wheat to barrel.	Remarks.
	Bush. lbs.	Bbls. lbs.		Bush. lbs.	Bush. lbs.	
1 Lancaster, Ohio...........	100.	26.	21 bbls. Family ; 5 bbls. Super...........	4. 1	3. 51	Wheat deliv'd to Miller already unbran'd
2 A. W. Fagan, St. Louis.....	2,000.	493. 162	372 bbls.Double Extra ; 121 & 162 lbs.Super	4. 12	4. 3 *	" " " " "
3 Goodwin, Miller & Co.......	95. 17	24. 33	18 & 90 lbs. XX ; 5 & 87 lbs. S.; 52 lbs. Com.	Not weigh'd.	3. 56½	" " " " "
4 Ditto.....................	53.	13. 85	10 bbls. & 22 lbs. XX ; 3 bbls.,63 lbs. Super	" "	3. 57	" " " " "
5 Ditto.....................	548. 8	133. 104	100 bbls. & 104 lbs. XX ; 33 bbls. Super...	4. 6	Not weigh'd.	Wheat weighed when crude.
6 C. S. Smith, Portsmouth, O.	200.	49.	All Extra..............................	4. 5	" "	" " " "
7 Ditto.....................	672.	166.	Family and Super.......................	4. 3	" "	" " " "
8 Gover's Mill	100.	25. 39	23 bbls. & 163 lbs. XX ; 1 bbl., 72 lbs. Fine	Not weigh'd.	3. 58½	Wheat deliv'd to Miller already unbran'd
9 Ditto.....................	100.	25. 120	All Extra..............................	" "	3. 55½	" " " " "

* The offal from this grinding was left too rich.—1000 lbs. of it being re-ground, yielded 360 lbs. flour. In this mill, when making—by ordinary mode of grinding—Double Extra or Family, and Super, (66 to 75 per cent. of former, and 33 to 25 per cent. of latter,) 4 bush. and 40 lbs. average of first-class wheat are required to make a barrel of flour ; and 73 lbs. is the average quantity of offal for each barrel of flour.

In the first four and the last two grindings, the bushels in 2d column are bushels of unbranned wheat. In the 5th, 6th and 7th grindings, the figures in 2d column indicate bushels of crude wheat.